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Zaharia et al.

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(54) **MANAGED METASTORAGE**

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G06F 21/62 (2013.01)
G06F 3/06 (2006.01)

(52) **U.S. Cl.**

CPC ***G06F 21/62*** (2013.01); ***G06F 3/0604*** (2013.01); ***G06F 3/0655*** (2013.01); ***G06F 3/0673*** (2013.01)

(58) **Field of Classification Search**

CPC G06F 21/62; G06F 3/0604; G06F 3/0655; G06F 3/0673; G06F 3/0622; G06F 3/0637; G06F 21/6218; G06F 3/067

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,594,922	B1 *	3/2017	McGuire	H04L 9/08
11,200,331	B1 *	12/2021	Bouaichi	H04L 9/0897
2014/0172808	A1 *	6/2014	Burge	G06F 21/604 707/694
2014/0282192	A1 *	9/2014	Grossman	G06F 16/285 715/771
2015/0149441	A1 *	5/2015	Nica	G06F 16/24542 707/719
2016/0034547	A1 *	2/2016	Lerios	G06F 16/24537 707/602
2021/0279365	A1 *	9/2021	Apsingekar	H04L 63/0442

* cited by examiner

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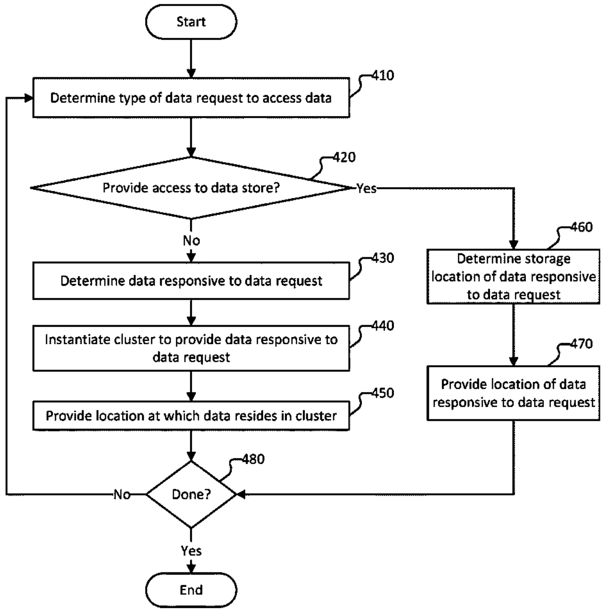
(57) **ABSTRACT**

The present application discloses a method, system, and computer system for providing access to information stored on system for data storage. The method includes receiving a data request from a user, determining data corresponding to the data request, determining whether the user has requisite permissions to access the data, and in response to determining that the user has requisite permissions to access the data: determining a manner by which to provide access to the data, wherein the data comprises a filtered subset of stored data, and generating a token based at least in part on the user and the manner by which access to the data is to be provided.

20 Claims, 6 Drawing Sheets


Start
Determine type of data request to access data
410
Provide access to data store?
420
Yes
No
Determine data responsive to data request
430
Instantiate cluster to provide data responsive to data request
440
Provide location at which data resides in cluster
450
Determine storage location of data responsive to data request
460
Provide location of data responsive to data request
470
Done?
480
No
Yes
End

400

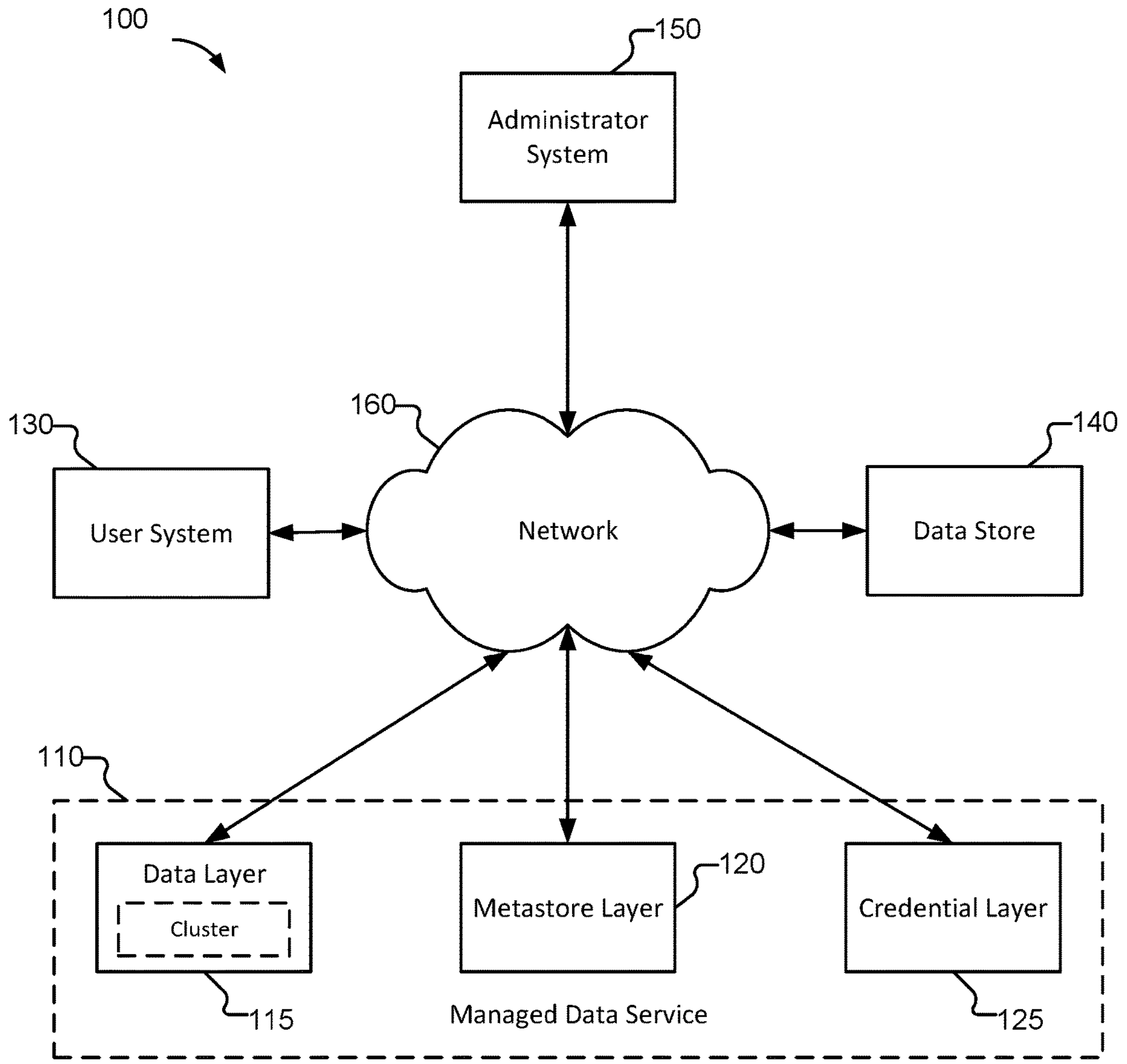

100
150
Administrator System
160
130
User System
Network
140
Data Store
110
Data Layer
Cluster
115
Metastore Layer
120
Credential Layer
125
Managed Data Service

FIG. 1

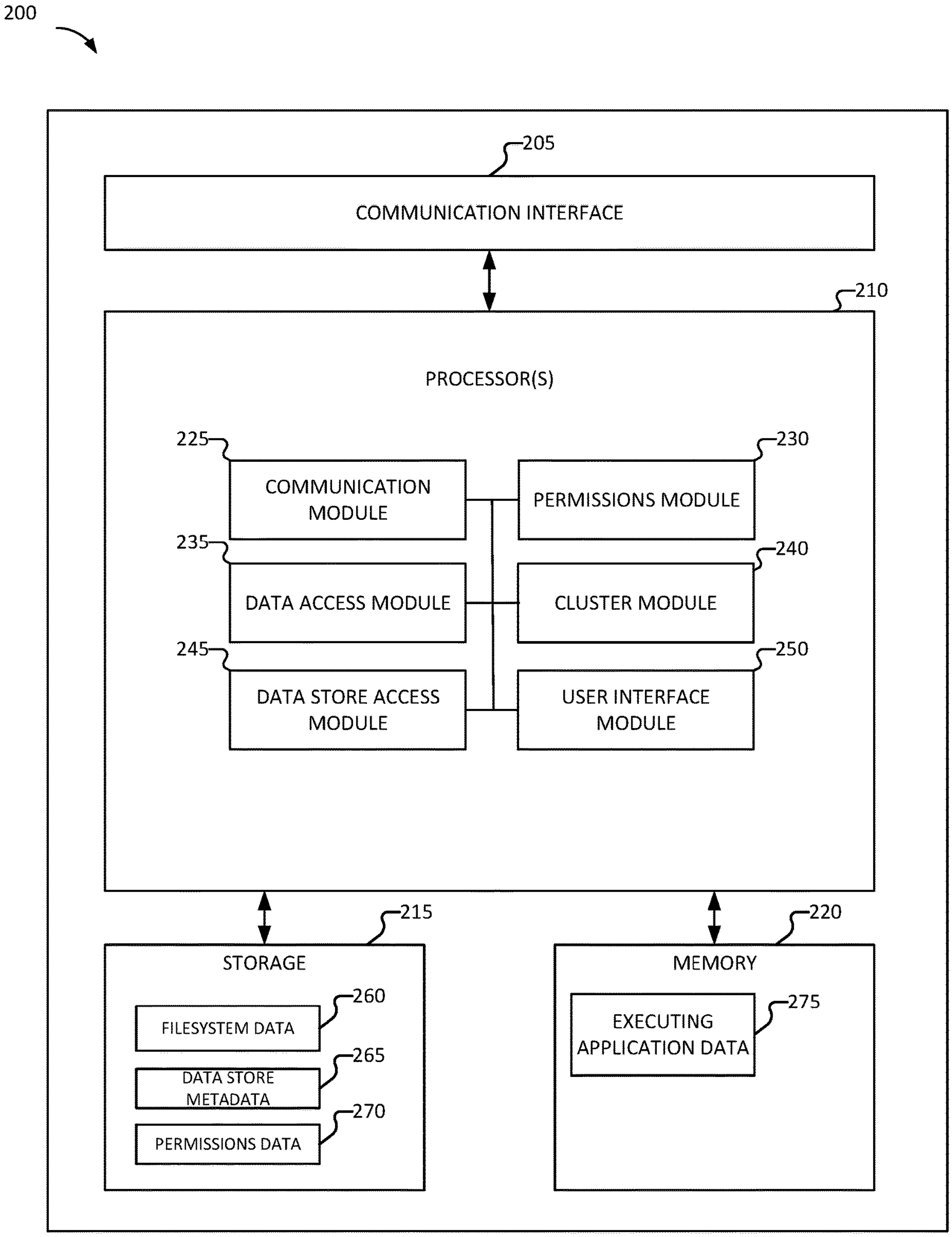

200
205
COMMUNICATION INTERFACE
210
PROCESSOR(S)
225
COMMUNICATION MODULE
230
PERMISSIONS MODULE
235
DATA ACCESS MODULE
240
CLUSTER MODULE
245
DATA STORE ACCESS MODULE
250
USER INTERFACE MODULE
215
STORAGE
260
FILESYSTEM DATA
265
DATA STORE METADATA
270
PERMISSIONS DATA
220
MEMORY
275
EXECUTING APPLICATION DATA

FIG. 2

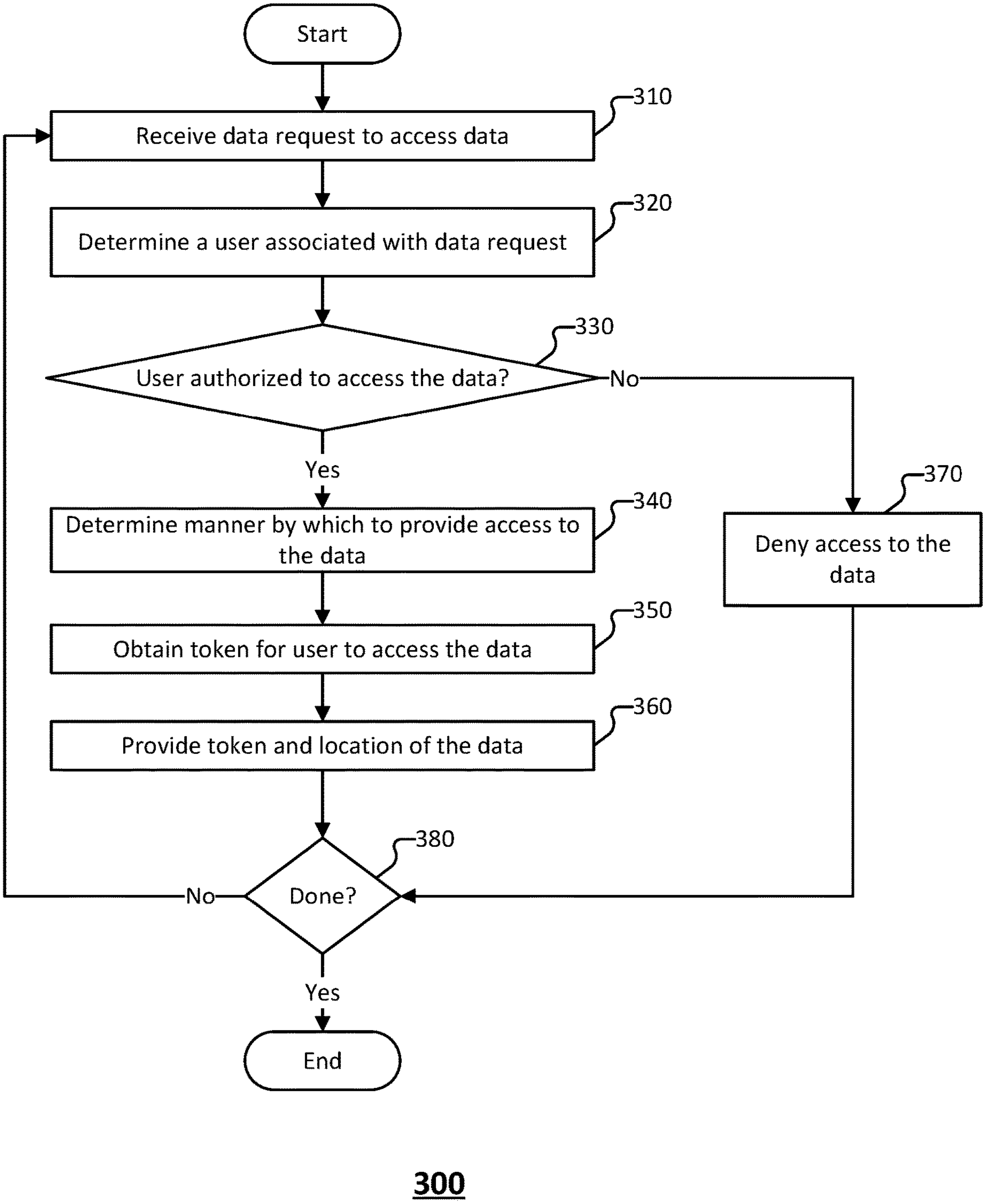

Start
310
Receive data request to access data
320
Determine a user associated with data request
330
User authorized to access the data?
No
Yes
340
Determine manner by which to provide access to the data
370
Deny access to the data
350
Obtain token for user to access the data
360
Provide token and location of the data
380
Done?
No
Yes
End
300

FIG. 3

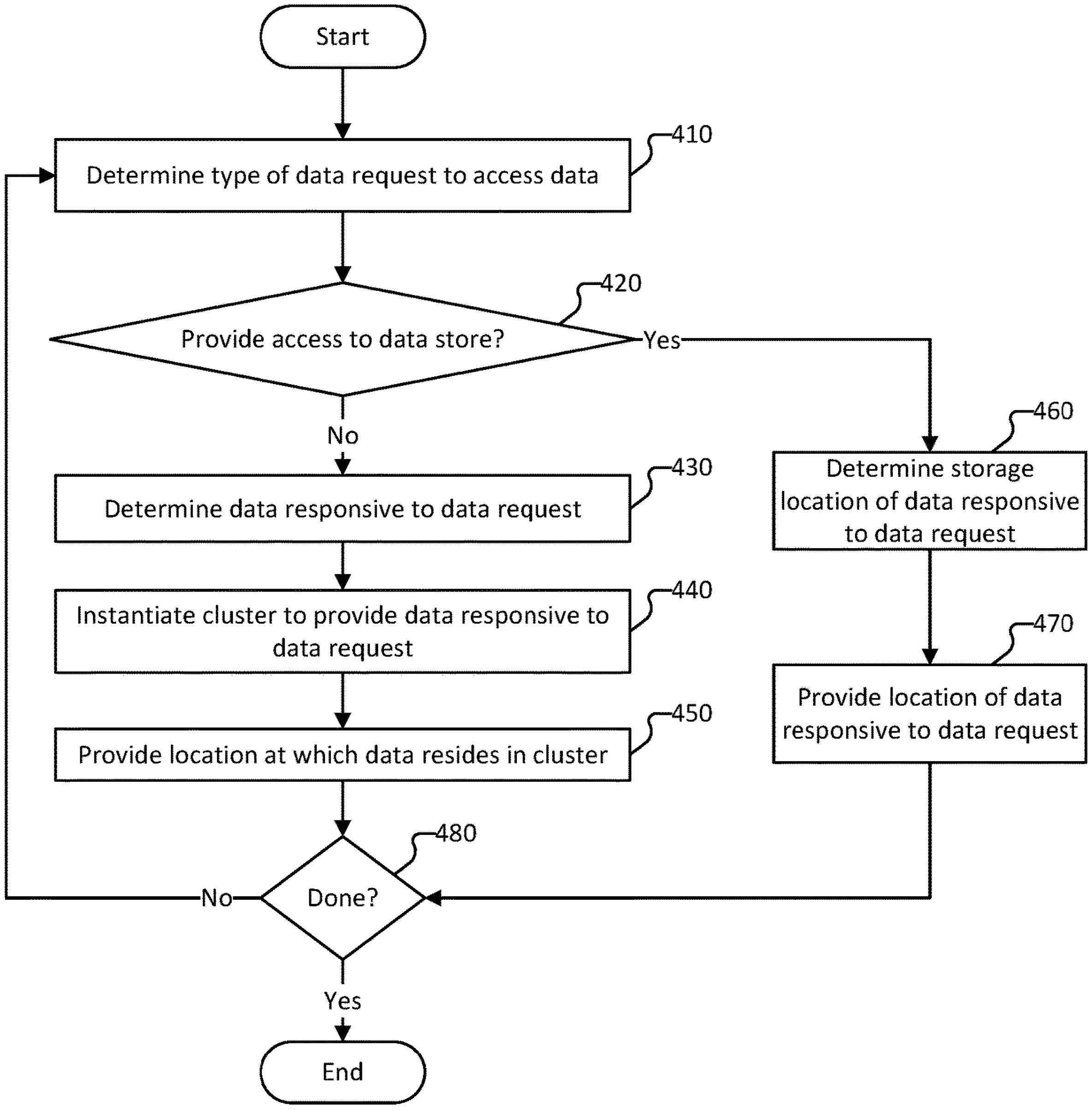

Start
Determine type of data request to access data
410
Provide access to data store?
420
Yes
No
Determine data responsive to data request
430
Instantiate cluster to provide data responsive to data request
440
Provide location at which data resides in cluster
450
Determine storage location of data responsive to data request
460
Provide location of data responsive to data request
470
Done?
480
No
Yes
End
400

FIG. 4

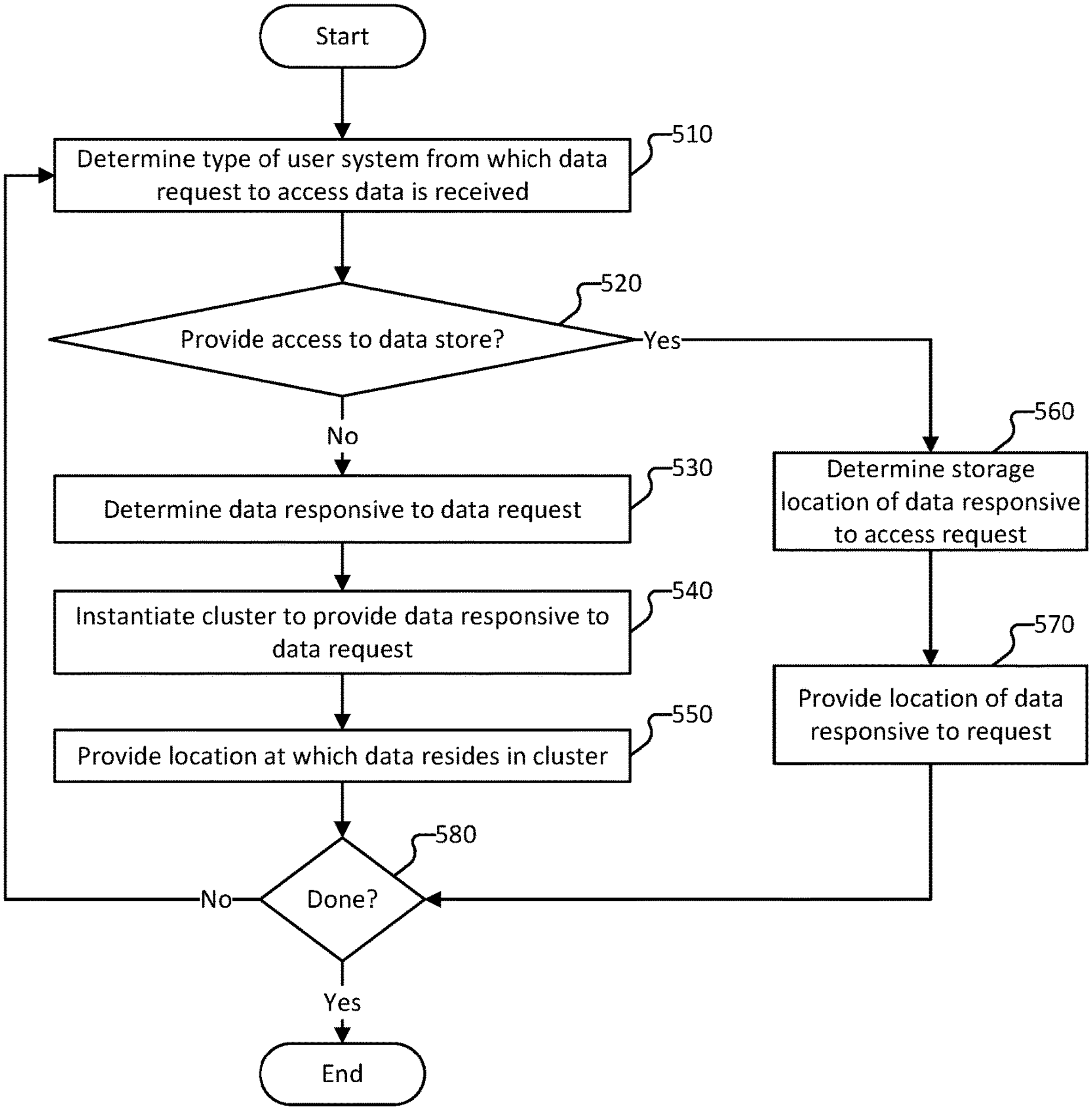

Start
Determine type of user system from which data request to access data is received
510
Provide access to data store?
520
Yes
No
Determine data responsive to data request
530
Instantiate cluster to provide data responsive to data request
540
Provide location at which data resides in cluster
550
Determine storage location of data responsive to access request
560
Provide location of data responsive to request
570
Done?
580
No
Yes
End
500

FIG. 5

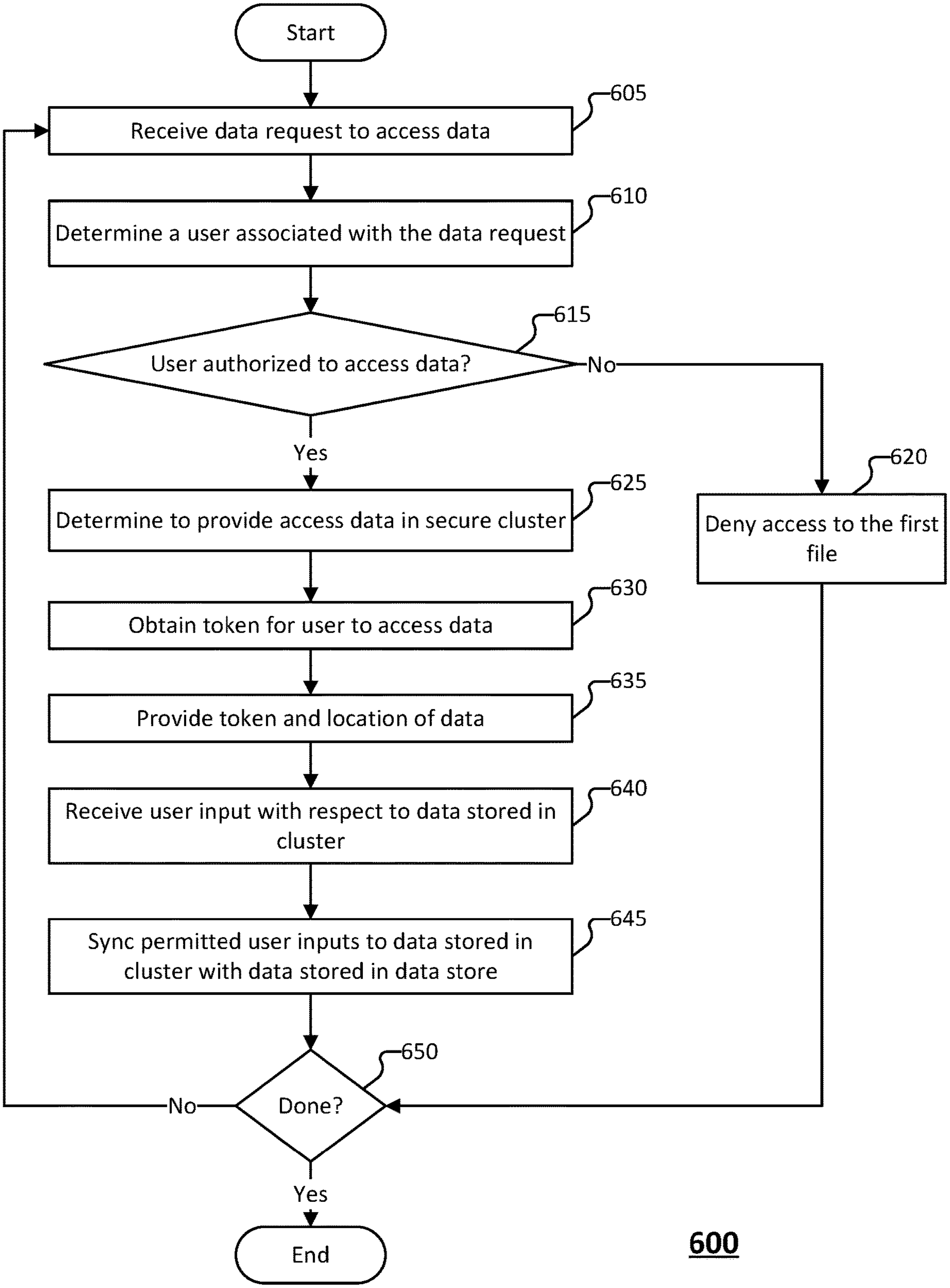

Start
Receive data request to access data
605
Determine a user associated with the data request
610
User authorized to access data?
615
No
Yes
Determine to provide access data in secure cluster
625
Deny access to the first file
620
Obtain token for user to access data
630
Provide token and location of data
635
Receive user input with respect to data stored in cluster
640
Sync permitted user inputs to data stored in cluster with data stored in data store
645
Done?
650
No
Yes
End
600

FIG. 6

MANAGED METASTORAGE

CROSS REFERENCE TO OTHER APPLICATIONS

This application claims priority to U.S. Provisional Patent Application No. 63/190,591 entitled MANAGED METASTORE filed May 19, 2021 which is incorporated herein by reference for all purposes.

BACKGROUND OF THE INVENTION

A system for big data processing comprises a system for deployments of applications, configurations, one or more datasets, and model(s) used in connection with analyzing the data. Data is often stored in a manner that does not facilitate granular data access control enforcement and coarse-grained controls available to enforce access control are unintuitive and often unfamiliar to most users. For example, data stored in a system for data storage for big data processing is often stored in tables comprising numerous rows and columns. This creates a problem for maintaining data security for data stored in a system for data storage that is accessible to numerous users.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of the invention are disclosed in the following detailed description and the accompanying drawings.

FIG. **1** is a block diagram of a network system according to various embodiments of the present application.

FIG. **2** is a block diagram of a managed data service system according to various embodiments of the present application.

FIG. **3** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application.

FIG. **4** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application.

FIG. **5** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application.

FIG. **6** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application.

DETAILED DESCRIPTION

The invention can be implemented in numerous ways, including as a process; an apparatus; a system; a composition of matter; a computer program product embodied on a computer readable storage medium; and/or a processor, such as a processor configured to execute instructions stored on and/or provided by a memory coupled to the processor. In this specification, these implementations, or any other form that the invention may take, may be referred to as techniques. In general, the order of the steps of disclosed processes may be altered within the scope of the invention. Unless stated otherwise, a component such as a processor or a memory described as being configured to perform a task may be implemented as a general component that is temporarily configured to perform the task at a given time or a specific component that is manufactured to perform the task. As used herein, the term 'processor' refers to one or more devices, circuits, and/or processing cores configured to process data, such as computer program instructions.

A detailed description of one or more embodiments of the invention is provided below along with accompanying figures that illustrate the principles of the invention. The invention is described in connection with such embodiments, but the invention is not limited to any embodiment. The scope of the invention is limited only by the claims and the invention encompasses numerous alternatives, modifications and equivalents. Numerous specific details are set forth in the following description in order to provide a thorough understanding of the invention. These details are provided for the purpose of example and the invention may be practiced according to the claims without some or all of these specific details. For the purpose of clarity, technical material that is known in the technical fields related to the invention has not been described in detail so that the invention is not unnecessarily obscured.

As used herein, a system for data storage refers to a cloud storage, a blob storage, or other storage system in which data is stored across a plurality of devices such as servers.

As used herein, a cluster refers to a set of connected nodes (e.g., computers, virtual machines, etc.) that work together. As an example, each node runs its own instance of an operating system.

According to various embodiments, a system, method, and/or device for providing access to data stored in a system for data storage is disclosed. The system comprises one or more processors and a memory. The one or more processors are configured to receive a data request from a user, determine data corresponding to the data request, determine whether the user has requisite permissions to access the data, and in response to determining that the user has requisite permissions to access the data: (i) determine a manner by which to provide access to the data, wherein the data comprises a filtered subset of stored data, and (ii) generate a token based at least in part on the user and the manner by which access to the data is to be provided.

In some embodiments, in response to generating the token, the system provides the token and/or a location at which the data is to be accessed (e.g., a location at which the data is accessible such as in connection with use of the token for authentication). For example, the system provides the token and/or the location at which the data is to be accessed to a user system or other system from which the data request is received. The token and/or the location may be comprised in a uniform resource locator (URL) or uniform resource identifier (URI). In some embodiments, in response to receiving the token, the user system can access the data directly (e.g., without further mediation from the metastore at least with respect to such data and/or for such length of time that the token remains valid).

According to various embodiments, the system (e.g., a managed data service, a metastore layer of the managed data service, etc.) determines a manner by which to provide access to the data. In some embodiments, the manner by which to provide access to the data comprises instantiating a cluster and providing access (e.g., a token and location for data on the cluster) to the data on the cluster. For example, the cluster is instantiated and the data is copied to the cluster from the system for data storage. In some embodiments, a cluster comprises a single node cluster. In some embodiments, the manner by which to provide access to the data comprises providing access to a location at which the data is stored on the system for data storage. As an example, the system determines whether to provide access to the data by (i) instantiating a cluster and providing access to the data stored on the cluster, or (ii) providing access to a location at which the data is stored on the system for data storage. For example, the system selects the manner by which to provide access to the data from (i) or (ii) above based at least in part on one or more of (a) a user system from which the data request to access data is received, (b), a user associated with the data request, (c) a type of data requested, (d) a context of the data request, (e) a determination that the user system from which the data request is received is not a managed or protected user system (e.g., that the user system is not a privilege-enforcing client), (f) an amount of memory that a user associated with a data request has permission to access, (g) an indication in the data request of the manner by which the data is to be accessed (e.g., via a secure cluster, or to system for data storage), etc. Examples of the context of the data request include a date, a time, a geographic region of the data (e.g., a data location), a location of the user system, a group membership, a quality associated with a user, applications being executed contemporaneous with the data request (e.g., executed on a server of the system, by the user system, etc.), other requests or other data obtained by the corresponding user or user system within a predetermined threshold period of time, etc.

Various embodiments include a protocol for enforcing fine grained data access permissions to untrusted applications running over a system for data storage (e.g., a managed storage system), where the access service (e.g., the managed data service) grants scoped access tokens understood by the underlying system (e.g., S3 pre-signed URLs, Amazon Web Services Security Token Service tokens, Azure Shared Access Signature tokens, etc.) to each application to give the application access only to the data the application needs. When the data granularity required is smaller than one file, the access service automatically filters down the file and possibly caches this result to give the filtered result (e.g., a filtered subset of stored data) to the applications. The filtering of the data allows trusted or untrusted applications running on behalf of a user to access just that user's data efficiently without being granted access to the whole underlying storage system (e.g., the system for data storage) and without requiring all the data to be streamed through a filtering service.

In some embodiments, the system determines to not provide a user (or user system or application running on the system) with access to the location at which the data is stored on the system for data storage (e.g., restrict access of data stored at the system for data storage) in response to determining that the user system from which the data request is received is a privilege-enforcing client. As an example, a privilege-enforcing client may be a device that is managed by an organization (e.g., a customer that owns the data stored on the system for data storage) such as in a manner that enforces one or more security policies for the organization or for particular types of information. A device that is managed may include a device that is subject to an organization's deployment of a unified endpoint and enterprise mobility management for mobile devices. According to various embodiments, in response to determining that the system from which the data request is received is not a privilege-enforcing client, the system determines to provide access to the data via instantiating a cluster, copying the data to the cluster, and providing access to the data stored on the cluster. In some embodiments, in response to determining that the user system corresponds to a device that is privilege-enforcing, the system determines to provide the user system with access to a location at which the data is stored on the system for data storage. For example, with respect to a privilege-enforcing device, the system deems the device able to perform a data transformation to provide a user with only such data that the user has authorization to access (e.g., the privilege-enforcing device locally enforces one or more security policies such as with respect to data of the organization). In some embodiments, with respect to non-privilege-enforcing devices (e.g., user systems), the system determines (e.g., computes) a set of data that the user associated with the user system should be able to access/view (e.g., the data that the user has privileges to access, the data that is available for access from a non-privilege-enforcing device, etc.), and access to such data is provided. As an example, the system determines the set of data that the user should be able to access contemporaneously with a data request to access data. If the system (e.g., managed data service) determines that the user (or application or user system) is not to be provided with access to an entire dataset or directory, the system may determine to provide access to certain data (e.g., a filtered subset of stored data) via instantiating a cluster, copying the certain data to the cluster, and providing access to the certain data stored on the cluster. According to various embodiments, in response to determining to provide the user with access to data via an instantiation of a cluster storing the data, the system (e.g., the managed data service, or a metastore layer of the managed data service) determines the data for which the user is authorized to access and/or the data that is responsive to the data request, and the system instantiates the cluster, and the system creates on the cluster a table with the data for which the user is authorized to access and/or the data that is responsive to the data request. The system can create a table on the cluster based on invoking the system for data storage to create a table with certain data. As an example, the system identifies a location at which to create the table (or receives a location at which the cluster determined to create the table), causes the system for data storage to create the table, generates a token (e.g., a temporary token) to access the data at the location at which the table resides on the system for data storage, and provides to the user system the token and a path to the location.

In some embodiments, the certain data is stored in a new structure, file, table, or as values on the distributed storage system and access is provided to the certain data. In some embodiments, the system for data storage comprises a distributed data storage system.

In some embodiments, the system determines to provide a user (or user system or application running on the system) with access to the location at which the data is stored on the system for data storage (e.g., restrict access of data stored at the system for data storage) based at least in part on a user that communicated the data request. For example, the system determines whether to provide access to the location at which the data is stored on the system for data storage based on a level of permission that the user has with respect the data (e.g., the data subject to the request). The level of permission that a user has with respect to the data may be set by a user having administrator privileges or a user otherwise having privileges to grant access rights to other users. In response to determining that the user system from which the data request is received is privilege-enforcing client, the system may determine to provide access to a location at which the data is stored on the system for data storage. For example, providing access to a location at which the data is stored on the system for data storage comprises using the system for data storage to filter the data according to (i) data responsive to the data request, and (ii) permissions of the user or application requesting such data. According to various embodiments, in response to determining to provide the user with access to the location at which the data is stored on the system for data storage, the system (e.g., the managed data service, or a metastore layer of the managed data service) determines the data for which the user is authorized to access and/or the data that is responsive to the data request, and the system creates a table on the system for data storage corresponding to the data for which the user is authorized to access and/or the data that is responsive to the data request. The system can create a table on the system for data storage based on invoking the system for data storage to create a table with certain data. As an example, the system identifies a location at which to create the table, causes the system for data storage to create the table, generates a token to access the data at the location at which the table resides on the system for data storage, and provides to the user system the token and a path to the location.

According to various embodiments, data stored on the system for data storage (e.g., data that may be subject to a data request to access such data) includes tables, views, machine learning models, machine learning tracking data, features (e.g., features used in determining, training, executing models), information pertaining to features, developer workspace documents or information such as notebook and projects, dashboards, billing information, audit logs, information scheme of a table catalog, lineage and metadata information, secrets, information pertaining to management of secrets, information pertaining to mount the configuration of a distributed file system mounted to a system for data storage (e.g., mount points for the distributed file system, etc.), etc. Various other types of data can be stored on the system for data storage. In some embodiments, data stored on the system for data storage comprises tables within a root store on the system for data storage, and/or external tables that reside outside the root store.

According to various embodiments, access controls can be configured (and applied to) various types of information such as protected health information and personal identifiable information. The access controls for various types of information can be applied to (and enforced with respect to) various data comprising such information, such as files, columns in tables, etc. According to various embodiments, the data security controls are more granular. For example, in contrast to related art systems that comprise coarse-grained controls such as enforcing access to rows of data in a table, data security control according to various embodiments enables finer control such as a cell-level control, a row-level control, a column-level control, or a type of information-level of control. In some embodiments, security is enforced at a column level, at an attribute level, on a basis of an environment from which data is being accessed, etc. As an example, if security is enforced with respect to a column, to prevent a user from accessing data in other columns in a table, the system creates a new table comprising only the columns that the user is permitted to access. The new table can be further filtered to comprise only data that is responsive to the data request (e.g., to eliminate non-responsive columns or rows, etc.). As an example, if security is enforced with respect to an attribute, to prevent a user from accessing data having a specific attribute, the system creates a new table comprising the original table filtered to remove data having the specific attribute. For example, if a user is on a finance team and the finance team does not have permission to see personal information within the organization or a particular table, the system (e.g., the metastore) instructs the data store to only permit the user to access columns that do not have an associated attribute (e.g., the metastore can instruct the data store to create a new table with personal information filtered out, such as a new table corresponding to an initial table filtered to remove columns having the associated attribute such as an associated personal information attribute). Similarly, the system (e.g., the metastore) instructs causes a cluster to only permit the user to access columns that do not have an associated attribute such as by causing the cluster to filter out columns having an associated attribute or by only copying to the cluster only information that does not have the associated attribute (e.g., when instantiating a cluster in connection with providing data responsive to a data request).

According to various embodiments, the token (e.g., the credential provided in connection with the location at which the data is to be accessed) is generated to be time-limited, geographically limited, or any other appropriate limitation. For example, the token is temporarily valid for a predefined period of time. Upon expiration of the token, authentication of the token in connection with an attempt to access the data will be denied. In some embodiments, the managed data service of the system enforces the access to data stored on the system for data storage. For example, a metastore layer comprised in the managed data service determines a scope of data to which to provide access to the user. The scope of data to which to provide access to the user can correspond to a set of data for which the user (or user system or application) has permission to access. As another example, the scope of data to which to provide access to the user corresponds to a set of data (i) for which the user (or user system or application) has permission to access, and (ii) that is responsive to the data request. In response to the determination that the system is to provide access to the data via instantiating a cluster and providing access to the data stored on the cluster, the system generates a token to access the data at the location on the cluster (or a token to the cluster generally, etc.). In response to the determination that the system is to provide access to the data via providing access to a location at which the data is stored on the system for data storage, the system generates a token to access the data stored on the system for data storage (e.g., a token to access corresponding customer data stored on the system for data storage generally, a token for a table created on the system for data storage with data responsive to the data request, etc.).

An example of a process for providing data includes (1) a first user creates a view V (e.g., a view of a table of data, such as a subset of data within the table) which transforms data selected from table T, and the first user grants a second user to select from view V (e.g., to access data comprised in view V). (2) a second user sends a data request to the system to request access to data in view V (e.g., to read from view V). For example, the second user sends a request via an application program interface (API) that interfaces with an application on the system such as on a managed data service. As another example, the second user sends the data request to a business intelligence layer (or application running thereon), and managed data service (or a metastore layer of the managed data service) intercepts the data request and mediates the request for data between the second user and the system for data storage. (3) the system (e.g., the managed data service) determines that the request is from an external source (e.g., a non-privilege-enforcing device), and in response to such a determination, the system instantiates a cluster (e.g., or first determines whether a cluster has already been instantiated with data responsive to the data request), copies/writes the transformed data corresponding to view V to the cluster, and provides to the second user (e.g., the corresponding user system) a temporary credential (e.g., a token generated by the managed data service such as a token that remains valid for a predetermined amount of time, etc.) and a storage path to the transformed data on the cluster. (4) the second user reads the data from the storage path on the cluster. In some embodiments, the system decommissions the cluster after a predefined threshold period of time, after a threshold period of time has elapsed without a threshold number of data accesses or incoming requests, in response to a triggering event, in response to a cost analysis determination (e.g., a determination to decommission in response to a cost being higher for keeping the data around to read vs. reloading the data at a later time when requested again), based on a user settable value (e.g., a value indicating a user rating of importance for the data to be accessible), based on a past history of access frequency, based on a cost saving function, or based on any other appropriate manner of determining de-provisioning a cluster.

According to various embodiments, the system (e.g., the managed data service) logs an association among (i) use of a token, (ii) data that is exposed to a user or application in connection with the use of the token, and (iii) the user or application for which the token was used. Accordingly, the system can monitor/track data leaks or data views on a much more granular level than related art. For example, in related art systems, a token was issued from a database-controlled access service, and the related art database systems generally was not able to assess whether certain data should have been visible or not for a particular user (e.g., a related art database system does not provide access controls on a column-by-column basis for a table; rather related art systems provide data on a row-by-row basis).

An example of a process for providing data includes: (1) a first user sends a request to the system (e.g., the managed data service) to grant a second user access (e.g., to read) a table; (2) the system determines whether the first user has the requisite permission to grant the second user such permission to access the table; (3) in response to determining that the first user has the requisite permission to grant the second user such permission, the system (e.g., the managed data service, or the metastore layer of the managed data service) logs the permission such as writing the permission to an internal database; (4) second user sends a data request to the system to request access to data in view V (e.g., to read from view V)—for example, the second user sends a request via an application program interface (API) that interfaces with an application on the system such as on a managed data service; as another example, the second user sends the data request to a business intelligence layer (or application running thereon), and managed data service (or a metastore layer of the managed data service) intercepts the data request and mediates the request for data between the second user and the system for data storage; (5) the system (e.g., the managed data service) determines that the second user has the appropriate/requisite permissions to access (e.g., to read) the table; (6) in response to determining that the second user has the appropriate permissions to access the table, the system (e.g., the managed data service, or the metastore layer of the managed data service) creates a temporary credential (e.g., a token generated by the managed data service such as a token that remains valid for a predetermined amount of time, etc.) and a storage path to the table on the system for data storage; and (7) the second user reads the data from the table on the system for data storage. However, because the second user was granted a permission to read the table, the second user cannot modify data comprised in the table. In some embodiments, in this case, the user has permission to read the table and queries the metadata store, the metadata store sees that the user has permission to read the data in the metastore and responds with where to read the data from and the credentials to read the data. In some embodiments, in other cases, the user has partial access and the system provides access by writing the data out to an alternate location before giving the user access to that temp path to that alternate location.

According to various embodiments, a managed data service mediates access to a system for data storage. In some embodiments, a metastore layer intercepts a data request sent to the system for data storage. In some embodiments, a control layer intercepts a data request sent to the system for data storage, and the control layer provides or forwards the data request to the metastore layer for the metastore to mediate access to the system for data storage. In response to intercepting a data request, the metastore layer determines whether the user from which the data request originated has requisite permission to access the data corresponding to the data request (e.g., whether the user has access to the system for data storage or part thereof). In response to receiving a token from the metastore to access the data corresponding to the data request, the user can communicate with the system for data storage directly and use the token to access the corresponding data. For example, communicating with the system for data storage directly can correspond to communicating with the system for data storage without further mediation by the metastore (e.g., at least while the token being used is still valid).

In some embodiments, the system determines to not provide a user (or user system or application running on the system) with access to the location at which the data is stored on the system for data storage (e.g., restrict access of data stored at the system for data storage) in response to determining that an amount of data for which the user does not have access (e.g., the amount of data that the user is authorized to read based on the permissions policy). In some embodiments, in the event that the user is not provided with access to data, an indication is provided to the user (e.g., permission is denied to access the data). In response to determining amount of data user has access to exceeds a memory threshold, the system (e.g., the managed data service, or metastore layer of the managed data service) determines to provide the user with access to the data via instantiating a cluster and providing access to the data stored on the cluster. For example, the system causes the following data to be copied to the cluster: (i) data that the user is authorized to read, or (ii) data that the user is authorized to read and that is responsive to the data request. As an example, the system causes the cluster to create a table that comprises data that the user is authorized to read and that is responsive to the data request, and determines a location of the table. As an example, the system identifies a location at which to create the table (or receives a location at which the cluster determined to create the table), causes the system for data storage to create the table, generates a token (e.g., a temporary token) to access the data at the location at which the table resides on the system for data storage, and provides to the user system the token and a path to the location.

The system improves the security of data stored in system for data storages by enabling greater control with respect enforcing data access permissions. The system provides greater granularity of security enforcement. As an example, in contrast to related art systems, which merely provide enforcement of data access permissions on an entire dataset, or row of a dataset, systems according to various embodiments enable enforcement of data access permissions on a particular data item such as by enforcing security on a column-by-column basis or enforcing permissions on both a row and a column in conjunction. The system further improves security by providing access to certain data in a secure cluster such as a cluster that is instantiated specifically in response to a data request and to which filtered data is copied. As an example, the filtered data copied to the instantiated cluster may be selected to be only data accessible by (e.g., authorized for) the user.

In some embodiments, the system improves the computer by enabling single path access to data stored in multiple diverse types of storage systems to systems using cluster computing resources. In some embodiments, fine grained security for data is enabled for the data accessed regardless of whether the storage systems natively support this type of security. The system intermediates data access by determining the capabilities of the systems and then either providing appropriate credentials for accessing (e.g., user credentials, session credentials, storage system credentials, etc.) data in a fine grained access system or obtaining, filtering, and storing by generating a separate data structure to access that only includes data allowed to be accessed (e.g., based on the user, session, storage system, etc.) as well as a accessing mechanism (e.g., a URL, a URI, or other pointer). This makes access more efficient and more secure for users and for system providers and enables use of existing storage resources.

FIG. **1** is a block a diagram of a network system according to various embodiments of the present application.

In the example illustrated in FIG. **1**, system **100** includes managed data service **110**, user system **130**, data store **140**, and/or administrator system **150**. In some embodiments, managed data service **110** and/or data store **140** are integrated (e.g., combined into a layer or a single set of server(s)). In some embodiments, managed data service **110** comprises data layer **115**, metastore layer **120**, and/or credential layer **125**. In some embodiments, data layer **115** comprises a cluster (e.g., a cluster that managed data store instantiates). In some embodiments, data layer instantiates a cluster on one or more servers outside managed data service **110**. System **100** further includes one or more networks such as network **160** over which user system **130** and/or administrator system **150** communicates with managed data service **110** and/or data store **140**. In various embodiments, network **180** includes one or more of a wired network, and/or a wireless network such as a cellular network, a wireless local area network (WLAN), or any other appropriate network. In some embodiments, data layer **115**, metastore layer **120**, and/or credential layer **125** are respectively implemented by one or more servers. System **100** may include various other systems or devices.

According to various embodiments, data store **140** is a system for data storage. For example, data store **140** is a blob storage. In some embodiments, data store **140** comprises data for a plurality of customers of managed data service **110** (e.g., different organizations or tenants registered with managed data service **110**). As an example, the data for the plurality of customers is not physically divided or segregated. For example, data among the plurality of customers is segregated (e.g., the data is segmented using customer storage buckets respectively associated with a particular customer). In some embodiments, data stored in data store **140** is encrypted such as by using a token associated with a particular customer.

According to various embodiments, system **100** comprises managed data service **110**. In some embodiments, managed data service **110** manages access to data stored in data store **140** and/or providing such data to a user system **130** in a secure manner (e.g., in a manner that enforces one or more security policies). In some embodiments, access to data in the data store **140** is mediated by metastore layer **120** of managed data service **110**. For example, metastore layer obtains a temporary token in connection with a data request from user system **130**, and user system **130** uses the temporary token in connection with accessing data stored in data store **140** or an instantiated cluster (e.g., depending on permissions of the token and the path for the location of the data provided by metastore layer **120**). In some embodiments, after receiving the temporary token for the data corresponding to a data request, user system **130** can thereafter directly access data stored in the data store **140** (e.g., subsequent accesses are not mediated via metastore layer **120** at least until the temporary token has expired). As an example, subsequent data requests to access the data corresponding to the temporary token can be mediated by a control layer (not shown) of a service such as file system service that indexes data stored in data store **140**.

Metastore layer **120** mediates a data request for data stored in data store **140**. In some embodiments, metastore layer **120** stores metadata pertaining to data (e.g., files) stored on data store **140**. As an example, metastore layer **120** stores an index of files to file locations. Metastore layer **120** determines a manner by which a manner by which to provide access to the stored data in data store **140**. In response to determining the manner by which to provide access to the data, metastore layer **120** causes the data to be provided to the user in such a manner (e.g., creates on data store **140** a table corresponding to a data request, instantiates a secure cluster in which to provide data, etc.) and provides the user with a location (e.g., path, URL, URI, etc.) at which the data can be accessed (e.g., a location of a table in data store **140**, a location of an instantiated cluster, a location of a table on an instantiated cluster, etc.). In some embodiments, metastore layer **120** obtains (e.g., generates, requests, etc.) a token to provide to the user (e.g., user system **130**) for accessing data.

In connection with mediating a data request, metastore layer **120** determines whether a user (e.g., a user associated with the data request) or application is authorized to access such data (e.g., that the user has requisite permissions to access the data). For example, metastore layer **120** stores (or has access to) a mapping of permissions such as a mapping of user identifiers for permitted users to data, a mapping of user identifiers for permitted users to types of data, a mapping of user identifiers for permitted users to locations of data (e.g., directories, tables, views, tenants, etc.), a mapping of groups of users to data, etc. Metastore layer **120** can use a user identifier associated with a data request (e.g., included in the data request) to query the mapping of permissions in connection with determining whether the user is authorized to access the data corresponding to the data request. If the user or application is authorized to access such data, metastore layer **120** determines an extent of such authorization (e.g., read, write, modify, delete, create, etc.). In response to determining that the user is authorized to access the data stored on data store **140**, metastore layer **120** determines the manner by which to provide access to the data.

In some embodiments, metastore layer **120** generates or obtains a credential (e.g., a temporary token) with which a user is to access data corresponding to a data request. For example, managed data service **110** can comprise credential layer **125**, and metastore layer **120** obtains the token from credential layer **125**. As an example, in response to determining to provide the user with access to the data corresponding to a data request (e.g., and determining a path of a location at which the data is stored), metastore layer **120** sends a request to credential layer **125** for a credential to be generated for the user to use such credential to access the data at the location. The request for the credential can comprise one or more of an indication of a user (or set of users) to be associated with the credential (e.g., the user that is to use the credential to access the data), an indication of the location of the data for which the credential is to be used to access, an expiry date, and/or an invalidating condition (e.g., a number of uses for which the credential is valid), etc. In some embodiments, in response to obtaining or generating the credential, metastore layer **120** provides the credential to the user (e.g., user system **130**) such as in connection with the location at which the user is to access the data.

According to various embodiments, managed data store service **110** comprises credential layer **125**. In response to credential layer **125** receiving a request from metastore layer **120** for a credential (e.g., a temporary token), credential layer **125** generates and provides the credential to metastore layer **120** (e.g., which in turn provides the credential to user system **130**, etc.). As an example, credential layer **125** generates the credential based at least in part on one or more of an indication of a user (or set of users) to be associated with the credential (e.g., the user that is to use the credential to access the data), an indication of the location of the data for which the credential is to be used to access, an expiry date, and/or an invalidating condition (e.g., a number of uses for which the credential is valid), etc.

In some embodiments, metastore layer **120** stores a mapping of files to a hierarchical structure. For example, metastore layer **120** transforms the non-hierarchical manner by which data is stored in data store **140** to a hierarchical structure corresponding to a customer. In some embodiments, data store **140** comprises one or more datasets associated with a customer. For example, data store **140** stores files and data against which code (e.g., code being developed via a web interface at credential layer **125** via user system **130**) is run against such as in connection with testing the code.

According to various embodiments, managed data service **110** comprises data layer **115**. According to various embodiments, data layer **115** comprises a cluster (e.g., a cluster of machines such as virtual machines). As an example, the cluster comprises at least one master node and one or more worker nodes. Managed data service **110** can copy at least a subset of information from data store **140** to data layer **115** (e.g., a cluster instantiated on data layer **115**). For example, in response to determining that data corresponding to a data request is to be provided to a user, metastore layer **120** determines to provide the data via instantiating a cluster and providing access to the data stored on the cluster. In response to determining to provide the data via instantiating a cluster and providing access to the data stored on the cluster, metastore layer **120** causes a cluster to be instantiated such as on data layer **115** and copies the applicable data from data store **140** to the instantiated cluster. In some embodiments, the applicable data copied to the instantiated cluster corresponds to data (i) for which the user (or user system or application) has permission to access, and/or (ii) that is responsive to the data request. Metastore layer **120** obtains the location at which the cluster is instantiated and/or location at which the data is located on the instantiated cluster, and provides the corresponding location to the user. In some embodiments, in response to determining that the cluster has been instantiated, metastore layer **120** causes (e.g., instructs) the cluster to create a table comprising data that is responsive to the data request, and metastore layer **120** obtains a location of such table and provides the location of the table to the user. In some embodiments, data layer **115** maintains the cluster for a predetermined time or until a termination condition is satisfied. Examples of a termination condition include: (a) a user indicating that the data and/or cluster is no longer needed, (b) a number of data accesses to the cluster is less than a predefined access threshold within a predefined threshold period of time, (c) metastore layer **120** providing an instruction to terminate the cluster, (d) expiration of a predefined period of time, (e) receipt of an indication from data store **140** or metastore layer **120** that information copied to the cluster has changed at the data store **140**, etc. Various other termination conditions can be implemented.

According to various embodiments, system **100** comprises user system **130**. User system **130** is used by a user (e.g., a developer such as a developer of code, a developer of a model, a user of an organization associated with a one or more datasets stored at data store **140**, etc.) to communicate with managed data service **120** (e.g., metastore layer **120**, a cluster instantiated on data layer **115**, etc.) and/or data stored in data store **140**. As an example, user system **130** communicates with managed data service **110** via a web-interface. In some embodiments, a user uses user system **130** to develop code on a business application layer, which makes a call to managed data service or to data store **140** (e.g., such call being intercepted by metastore layer **120** or a control layer that provides the call to metastore layer **120**), to modify code at a business application (e.g., to execute code against data stored in data store **140**), to query data store **140** (e.g., in connection with discovering code, a library, a module, etc.), etc.

According to various embodiments, system **100** comprises an administrator system **150** for use by an administrator such as an administrator of managed data service **110** or an administrator of a customer associated with an instance or tenant being deployed by data layer **115** and/or data store **140**. For example, administrator system **150** comprises a system for communication, data access, computation, etc. An administrator uses administrator system **150** to maintain data store **140** (e.g. maintain raw data comprised in data store **140**), to define and manage applications provided by system **100**, etc. For example, an administrator uses administrator system **150** to define one or more security policies that are to be enforced (e.g., by metastore layer **120**) with respect to a data stored at data store **140**. Administrator system **150** communicates with managed data service **110** via a web-interface (e.g., by using a web browser, etc.). For example, administrator system **150** communicates with managed data service **110** via a web-browser installed on administrator system **150**. As another example, administrator system **150** communicates with managed data service **110** via an application running on administrator system **150**.

FIG. **2** is a block diagram of a managed data service system according to various embodiments of the present application. According to various embodiments, system **200** is implemented at least in part by system **100** of FIG. **1**. In some embodiments, system **200** implements at least part of process **300** of FIG. **3**, process **400** of FIG. **4**, process **500** of FIG. **5**, and/or process **600** of FIG. **6**.

In the example shown, system **200** implements one or more modules in connection with mediating data access for data stored at a system for data storage (e.g., a data store), enforcing security or data access policies with respect to such data, determining a manner by which the data is to be provided to a user, etc. System **200** comprises communication interface **205**, one or more processors **210**, storage **215**, and/or memory **220**. One or more processors **210** comprises one or more of communication module **225**, permissions module **230**, data access module **235**, cluster module **240**, data store access module **245**, and/or user interface module **250**.

In some embodiments, system **200** comprises communication module **225**. System **200** uses communication module **225** to communicate with various other systems such as a user system, an administrator system, and/or a data store (e.g., a system for data storage). For example, communication module **225** provides to communication interface **205** information that is to be communicated. As another example, communication interface **205** provides to communication module **225** information received by system **200**. Communication module **225** is configured to receive user input to a user system such as a data request for data stored in a data store, a request to access, or provide a user with results. The user input to the user system can include the creation of a new file, a modification or update to a file, a query for a file (e.g., a csv file, a library, a module, etc.), a request to set one or more security policies (e.g., a permission with respect to accessing a file or a directory), etc. For example, the user develops or requests execution of code in a workspace provided by a user system. Communication module **225** is configured to provide to various user systems information such as user interface (e.g., an interface corresponding to a workspace or notebook), information that is responsive to one or more queries or tasks requested to be executed, locations at which data is to be accessed, credentials for accessing data, etc.

In some embodiments, system **200** comprises permissions module **230**. System **200** uses permissions module **230** to manage and/or enforce permissions such as permissions with respect to data stored at a data store, or data stored on an instantiated cluster (e.g., a cluster instantiated with respect to managed data service). In some embodiments, permission module **230** stores mapping of permissions. Examples of permissions can include a mapping of user identifiers for permitted users to data, a mapping of user identifiers for permitted users to types of data, a mapping of user identifiers for permitted users to locations of data (e.g., directories, tables, views, tenants, etc.), a mapping of groups to data. In response to system **200** receiving a data request to access data, permissions module **230** determines whether the user associated with the data request has requisite permissions to access the data corresponding to the data request, data on the data store, data on the instantiated cluster, etc. For example, permissions module **230** performs a lookup or query to determine whether the data has requisite permissions.

In some embodiments, system **200** comprises data access module **235**. System **200** uses data access module **235** to determine a location at which data is stored on a data store, determine a manner by which the access to the data is to be provided to a user, and to determine a location at which system **200** provides access to the data. Data access module **235** can provide a location at which data is stored to permissions module **230** in connection with permissions module **230** determining whether a user has permission to access such data. In some response to system **200** determining that the user has permission to access the data, data access module **235** determines the manner by which system **200** is to provide access to the data. In some embodiments, the manner by which access is provided to the data comprises instantiating a cluster and providing access (e.g., a token and location for data on the cluster) to the data on the cluster. For example, the cluster is instantiated and the data is copied to the cluster from the system for data storage. In some embodiments, the manner by which to provide access to the data comprises providing access to a location at which the data is stored on the system for data storage. As an example, data access module **235** determines whether to provide access to the data by (i) instantiating a cluster and providing access to the data stored on the cluster, or (ii) providing access to a location at which the data is stored on the system for data storage. For example, data access module **235** selects the manner by which to provide access to the data from (i) or (ii) above based at least in part on one or more of (a) a user system from which the data request to access data is received, (b), a user associated with the data request, (c) a type of data requested, (d) a context of the data request, (e) a determination that the user system from which the data request is received is not a managed or protected user system (e.g., that the user system is not a privilege-enforcing client), (f) an amount of memory that a user associated with a data request has permission to access, (g) an indication in the data request of the manner by which the data is to be accessed (e.g., via a secure cluster, or to system for data storage), etc. Examples of the context of the data request include a date, a time, a geographic region of the data (e.g., a data location), a location of the user system, a group membership, a quality associated with a user, applications being executed contemporaneous with the data request (e.g., executed on a server of the system, by the user system, etc.), other requests or other data obtained by the corresponding user or user system within a predetermined threshold period of time, etc.

According to various embodiments, data access module **235** obtains a location at which the data is to be accessed and a credential to be used in connection with accessing the data. As an example, data access module **235** obtains the location at which the data is to be accessed from cluster module **240** and/or data store access module **245**. For example, in response to determining that the data is to be provided via instantiating a cluster, data access module **235** obtains (e.g., receives from the cluster module **240**, determines and instructs the cluster module, etc.) a location on the cluster at which the data (e.g., the data responsive to the data request) is to be accessed. As another example, in response to determining to provide access to the data at a location on the data store, data access module **235** determines a location on the data store at which the data is to be accessed (e.g., data access module **235** causes data store access module **245** to create a table comprising data responsive to the data request, etc.). Data access module **235** provides the location at which the data is to be accessed (e.g., a location on a cluster, a location on the data store, etc.) to a user such as to a user system in response to the data request. As an example, data access module **235** provides the location at which the data is to be accessed to the user system via user interface module **250** and/or data access module **235**.

In some embodiments, in connection with providing the location at which the data is to be accessed, data access module **235** provides to the user a credential with which the user is to access the data. As an example, the credential is a token. The token is generated to be time-limited. For example, the token is temporary for valid for a predefined period of time. Upon expiration of the token, authentication of the token in connection with an attempt to access the data will be denied. In some embodiments, data access module **235** generates the token such as in response to determining to provide the user with access to data. In some embodiments, data access module **235** obtains the token such as from another module (e.g., in response to requesting the token).

In some embodiments, system **200** comprises cluster module **240**. System **200** uses cluster module **240** to provide access to data via a cluster such as a secure cluster. Cluster module **240** can instantiate a cluster in response to the determination to provide access to the data via a cluster. For example, in response to data access module **235** determining to provide access to the data via instantiating a cluster and providing access to the data stored on the cluster. In some embodiments, cluster module **240** causes data that is to be provided via an instantiated cluster to be copied to the cluster from the data store (e.g., from the location at which the data is initially stored but to which system **200** determines not to provide the user with access. For example, cluster module **240** copies, to the cluster, data (i) for which the user (or user system or application) has permission to access, or (ii) for which the user has permission to access and that is responsive to the data request. In some embodiments, in connection with providing the data via a cluster, cluster module **240** creates on the cluster a table comprising the data for which the user has permission to access and that is responsive to the data request. Cluster module **240** provides to data locator module **235** a location on the cluster at which the data is to be accessed (e.g., by the user system).

In some embodiments, system **200** comprises data store access module **245**. System **200** uses data store access module **245** to provide access to the data at a location on the data store. As an example, in response to system **200** determining to provide access to the data on the data store, data store access module **245** causes the data store to filter the data according to one or more of (i) the permissions for the user (or user system or application), or (ii) data that is responsive to the data request. For example, data store access module **245** causes (e.g., instructs) the data store to create a table or view comprising the data for which the user has permission to access (e.g., to read). As another example, data store access module **245** causes (e.g., instructs) the data store to create a table or view comprising data satisfying both of the following conditions: (i) data for which the user has permission to access, and (ii) data that is responsive to the data request. Data store access module **245** determines a location on the data store at which the data is to be accessed, and data store access module **245** provides to data locator module **235** a location on the data store at which the data is to be accessed (e.g., by the user system).

In some embodiments, system **200** comprises user interface module **250**. System **200** uses user interface module **250** to provide information to a user system (e.g., a workspace, a notebook such as a user interface for code development, an interface for a web application, etc.). In some embodiments, user interface module **250** provides a credential and/or a location at which the data is to be accessed (e.g., a location at which the data is accessible such as in connection with use of a token for authentication). As an example, the credential and/or location as a selectable element (e.g., a hyperlink comprising the credential and/or the location). User interface module **250** can provide a workspace in a web user interface that is rendered at a user system (e.g., rendered in a web browser via which user system is accessing the system). User interface module **250** can further provide a user interface to administrator system **150** to enable an administrator to manage and/or configuring settings of system **200** or managed data service **110**. In some embodiments, user interface module **250** provides a user interface for various other applications such as applications provided by a business application layer.

According to various embodiments, storage **215** comprises one or more of filesystem data **260**, data store metadata **265**, and/or permissions data **270**. Storage **215** comprises a shared storage (e.g., a network storage system) and/or database data, and/or user activity data. In some embodiments, filesystem data **260** comprises a database such as one or more datasets (e.g., one or more datasets for one or more features, etc.). Filesystem data **260** comprises data such as a code being developed, code used in connection with development of a model, data generated in connection with executing code, modules imported into a workspace, etc. In some embodiments, filesystem data **260** comprises data pertaining to a cluster instantiated to provide data to a user. In some embodiments, data store metadata **265** comprises information pertaining to the data store and/or data stored on the data store. As an example, data store metadata **265** stores an index of data stored on the data store, location information indicating a location at which data is stored on the data store, etc. In some embodiments, permissions data **270** comprises information comprising one or more security policies, and/or permissions pertaining to data access for data on the data store. As an example, permissions data **270** stores a mapping of permissions such as a mapping of user identifiers for permitted users to data, a mapping of user identifiers for permitted users to types of data, a mapping of user identifiers for permitted users to locations of data (e.g., directories, tables, views, tenants, etc.), a mapping of groups of users to data, etc.

According to various embodiments, memory **220** comprises executing application data **275**. Executing application data **275** comprises data obtained or used in connection with executing an application such as an application executing in connection with providing the access to data stored on the data store, an application that enforces security of data in the data store, an application that monitors data and operations of the data store, an application that executes code being developed in a workspace. In some embodiments, the application comprises one or more applications that perform one or more of receive and/or execute a query or command, generate a report and/or configure information that is responsive to an executed query or command, and/or to provide to a user information that is responsive to a query or command. Other applications comprise any other appropriate applications (e.g., an index maintenance application, a communications application, a chat application, a web browser application, a document preparation application, a report preparation application, a user interface application, a data analysis application, an anomaly detection application, a user authentication application, a security policy enforcement application, a code analysis application, a code development application, etc.).

FIG. **3** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application. According to various embodiments, process **300** is implemented at least in part by system **100** of FIG. **1** and/or system **200** of FIG. **2**. In some embodiments, process **300** is implemented in connection with process **400** of FIG. **4**, process **500** of FIG. **5**, and/or process **600** of FIG. **6**,

At **310**, a data request to access data is received. In some embodiments, the system receives the data request from a user such as via a user system. For example, in response to a user inputting a request to an interface (e.g., a web interface), the user system communicates the request to the system. In some embodiments, the managed data service (e.g., the metastore layer of the managed data service) intercepts the data request, or a control layer intercepts the data request and provides the request to the managed data service. The data corresponding to the data request is stored in a data store.

At **320**, a user associated with the data request is determined. In response to receiving the data request, the system determines the user associated with the data request. For example, the system determines the user associated with the user system from which the data request is received. In some embodiments, the data request comprises information indicating a user (e.g., a user identifier, a user system identifier, etc.).

At **330**, a determination of whether the user is authorized to access the data is performed. The system determines whether the user is authorized to access the data based on a permissions set associated with the user, the data corresponding to the data request, and/or the location at which the data is stored. In some embodiments, the stores (or has access to) a mapping of permissions such as a mapping of user identifiers for permitted users to data, a mapping of user identifiers for permitted users to types of data, a mapping of user identifiers for permitted users to locations of data (e.g., directories, tables, views, tenants, etc.), a mapping of groups of users to data, etc. As an example, the system uses a user identifier associated with a data request (e.g., included in the data request) to query the mapping of permissions in connection with determining whether the user is authorized to access the data corresponding to the data request.

In response to determining that the user is authorized to access the data at **330**, process **300** proceeds to **340** at which a manner by which access to the data is to be provided. In some embodiments, the system determines whether to provide access to the data by (i) instantiating a cluster and providing access to the data stored on the cluster, or (ii) providing access to a location at which the data is stored on the system for data storage. For example, the system selects the manner by which to provide access to the data from (i) or (ii) above based at least in part on one or more of (a) a user system from which the data request to access data is received, (b), a user associated with the data request, (c) a type of data requested, (d) a context of the data request, (e) a determination that the user system from which the data request is received is not a managed or protected user system (e.g., that the user system is not a privilege-enforcing client), (f) an amount of memory that a user associated with a data request has permission to access, (g) an indication in the data request of the manner by which the data is to be accessed (e.g., via a secure cluster, or to system for data storage), etc. Examples of the context of the data request include a date, a time, a geographic region of the data (e.g., a data location), a location of the user system, a group membership, a quality associated with a user, applications being executed contemporaneous with the data request (e.g., executed on a server of the system, by the user system, etc.), other requests or other data obtained by the corresponding user or user system within a predetermined threshold period of time, etc.

In some embodiments, determining the manner by which the data is to be provided comprises determining a location at which the data is to be provided. For example, the system determines whether to provide the data on an instantiated cluster and a location on the instantiated cluster at which the data is to be accessed by the user. As another example, the system determines whether to provide the data on the data store on which the data is stored, and a location of the data store at which the data is to be accessed by the user (e.g., a table or view can be created specifically to provide the data to the user in response to the data request).

At **350**, a token to be used in connection with accessing the data is obtained. In some embodiments, the system obtains the token based at least in part on one or more of the user associated with the data request (e.g., the user for whom the token is being provided), a location of the data, a system on which the location to be provided is stored (e.g., an instantiated secure cluster, the data store, etc.), etc. As an example, the system generates the token in response to determining that the user is authorized to access the data. As another example, the system requests that a credential system or an authentication system generates the token (e.g., based on parameters provided by the system such as comprised in the request for the token). In some embodiments, the token is time-limited (e.g., temporary, expires after a predetermined or preset amount of time, at a preset time, etc.), user-allowable-action-limited (e.g., the token is limited in what it allows the user to do—for example, it may allow modifying the existing data, adding new data, reading data, etc.), scope-limited (e.g., the credential is valid only with respect to a certain set of data such as data corresponding to the user access permissions, etc.), and/or action-limited (e.g., in response to an action or when thing X happens and causes the token to expire—for example, X=logging out, being removed from a group, the underlying data has changed, new data being added to the table, a permission being revoked or modified, an ownership being changed, other users being given write tokens to the data, etc.).

At **360**, the token and a location of the data is provided. In some embodiments, the system sends the token and the location of the data to the user (e.g., the user system). The token and/or the location may be comprised in a URL or a URI. In some embodiments, in response to receiving the token, the user system can access the data directly (e.g., without further mediation from the metastore at least with respect to such data and/or for such length of time that the token remains valid).

In response to determining that the user is not authorized to access the data at **330**, process **300** proceeds to **370** at which access to the data is denied. In some embodiments, denying access comprises providing a notice to a user system. As an example, the notice indicates that the user does not have permission to access the data corresponding to the data request. The notice can be provided on a user interface at the user system (e.g., a web interface via which the user system communicates with managed data service, the data store, etc.).

At **370**, a determination is made as to whether process **300** is complete. In some embodiments, process **300** is determined to be complete in response to a determination that no further commands are to be performed or that no further data is to be accessed, a user has indicated that no further data is to be accessed, the user has exited the system, an administrator indicates that process **300** is to be paused or stopped, a determination that a fault occurred at the data store or in execution of code via the workspace, etc. In response to a determination that process **300** is complete, process **300** ends. In response to a determination that process **300** is not complete, process **300** returns to **310**.

FIG. **4** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application. According to various embodiments, process **400** is implemented at least in part by system **100** of FIG. **1** and/or system **200** of FIG. **2**. In some embodiments, process **400** is implemented in connection with process **300** of FIG. **3**, process **500** of FIG. **5**, and/or process **600** of FIG. **6**.

At **410**, a type of data request to access data is determined. In some embodiments, the data request comprises an indication of whether the data is to be provided via a secure cluster (e.g., an instantiated cluster) or at a location on the data store. For example, creating a table or view pertaining to information that the user is authorized to access may take significantly longer on a data store than on an instantiated cluster, thus the user may determine to request that the responsive data be provided via an instantiated cluster. As another example, if a system deems a user or user system to be insecure, the data request may also be deemed insecure and thus be used in connection with determining to provide the data via an instantiated cluster. In some embodiments, the system determines the type of data request based on whether all or some of the data responsive to the data request is comprised in the data store.

At **420**, a determination of whether to provide access to the data store is performed. In some embodiments, the system determines to provide data responsive to the data request based at least in part on a type of data request. For example, if the data request does not comprise an indication of a request for the data to be provided via an instantiated cluster, or if the data request comprises an indication that the providing the data on the data store is being requested, the system determines whether to provide the data via access to the data store based at least in part on the indication(s).

In some embodiments, if the system determines that the data responsive to the data request is not all within the data store (e.g., that data from another data source is to be obtained in connection with providing a response to the data request), the system determines not to provide access to the data store. For example, the system determines to instantiate a cluster, and copy to the cluster pertinent data from the data store, and pertinent data from one or more other data sources that comprise information used to respond to the data request.

In response to determining not to provide access to the data store at **420**, process **400** proceeds to **430** at which data responsive to the data request is determined. In some embodiments, **430** is provided before **420** and the determination of whether to provide access to the data store comprises determining whether to provide access to the specific data that is responsive to the data request.

At **440**, a cluster is instantiated to provide data responsive to the data request. In some embodiments, the system determines one or more configurations for the cluster. For example, the one or more configurations are determined based on at least in part on one or more of (i) a user associated with the data request, (ii) a quality of service associated with the user or a customer with which the user is affiliated, (iii) a size of the data that is responsive to the data request, (iv) one or more security policies pertaining to the data, the user, or the user system, etc.

At **450**, the location at which data resides in the cluster is provided. In some embodiments, the system sends the location of the data in the cluster to the user (e.g., the user system). For example, the system provides to the user a location of a table or view created in response to the data request (e.g., a table or view created in response to a request sent by the system to the cluster, etc.). The location of the data can be provided via a selectable element such as a hyperlink to a URL or a URI. In some embodiments, the location is provided contemporaneously with a token (e.g., a temporary token). The token and/or the location may be comprised in a URL or URI. In some embodiments, in response to receiving the token, the user system can access the data directly (e.g., without further mediation from the metastore at least with respect to such data and/or for such length of time that the token remains valid).

In response to determining to provide access to the data store at **420**, process **400** proceeds to **460** at which a storage location of data responsive to the data request is determined. In some embodiments, the system determines where on the data store the data responsive to the data request is stored. For example, the system queries an index pertaining to a mapping of data to locations of data in the data store. As another example, the system queries the data store for an indication of the location at which the data is stored. As another example, the system requests the data store to create a table or view comprising the data corresponding to the data request, and the system determines (e.g., receives) the location of such data (e.g., of the table or view).

At **470**, location of data responsive to the data request provided. In some embodiments, the system sends the location of the data on the data storage to the user (e.g., the user system). For example, the system provides to the user a location of a table or view created in response to the data request (e.g., a table or view created in response to a request sent by the system to the data store, etc.). The location of the data can be provided via a selectable element such as a hyperlink to a URL or a URI. In some embodiments, the location is provided contemporaneously with a token (e.g., a temporary token). The token and/or the location may be comprised in a URL or a URI. In some embodiments, in response to receiving the token, the user system can access the data directly (e.g., without further mediation from the metastore at least with respect to such data and/or for such length of time that the token remains valid). The location at which the data is provided can correspond to a filtered subset of data corresponding to data that is responsive to the data request (e.g., the subset of data can be filtered from a set of data from stored data in the data store and/or a set of data for which the user has access permissions).

At **480**, a determination is made as to whether process **400** is complete. In some embodiments, process **400** is determined to be complete in response to a determination that no further commands are to be performed or that no further data is to be accessed, a user has indicated that no further data is to be accessed, the user has exited the system, an administrator indicates that process **400** is to be paused or stopped, a determination that a fault occurred at the data store or in execution of code via the workspace, etc. In response to a determination that process **400** is complete, process **400** ends. In response to a determination that process **400** is not complete, process **400** returns to **410**.

FIG. **5** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application. According to various embodiments, process **500** is implemented at least in part by system **100** of FIG. **1** and/or system **200** of FIG. **2**. In some embodiments, process **500** is implemented in connection with process **300** of FIG. **3**, process **400** of FIG. **4**, and/or process **600** of FIG. **6**.

At **510**, a type of user system from which a data request for accessing data is received. In some embodiments, the system determines whether the data request is received from a privilege-enforcing user system. As an example, a privilege-enforcing client may be a device that is managed by an organization (e.g., a customer that owns the data of the data stored on the system for data storage) such as in a manner that enforces one or more security policies for the organization or for particular types of information. A device that is managed may include a device that is subject to an organization's deployment of a unified endpoint and enterprise mobility management for mobile devices. According to various embodiments, in response to determining that the system from which the data request is received is not a privilege-enforcing client, the system determines to provide access to the data via instantiating a cluster, copying the data to the cluster, and providing access to the data stored on the cluster. In some embodiments, depending on the data and the access restrictions defined around it, a user is given direct access to the data (e.g., a user requests access to an entire table, a user has permission to an entire table, and is granted access to the entire table, etc.).

At **520**, a determination of whether to provide access to the data store is performed. The system determines whether to provide access to the data store based at least in part on the type of user system from which the data request is received. As an example, the system determines whether the user system is deemed secure. For example, the system determines whether the user system is configured to enforce security (e.g., at least with respect to the data responsive to the data request) locally at the user system. The system can determine whether to provide access to the data store based at least in part on whether the user system is secure. For example, if the user system is deemed insecure, the system determines to provide access to the data via an instantiated cluster, and if the system is deemed secure, the system determines to provide access to the data via the data store.

In some embodiments, the system distinguishes between clients that enforce the access control model and those that do not. For trusted clients, full access and instructions on how and what data to return to the user. For untrusted clients, there are two ways to mediate access: 1) using a cluster or other computing base to do the data filtering and write the data back out to the data storage; The location is then returned to the client requesting the data access as if it were simplu the raw data. the client does not need to know that the data was filtered or not filtered; and 2) the cluster is used to perform the filtering and the filtered results are streamed the back over the network.

According to various embodiments, in response to determining that the system from which the data request is received is not a privilege-enforcing client, the system determines to provide access to the data via instantiating a cluster, copying the data to the cluster, and providing access to the data stored on the cluster.

In response to determining not to provide access to the data store at **520**, process **500** proceeds to **530** at which data responsive to the data request is determined. In some embodiments, **530** corresponds to, or is similar to, **430** of process **400** of FIG. **4**.

At **540**, a cluster is instantiated to provide data responsive to the data request. In some embodiments, **540** corresponds to, or is similar to, **440** of process **400** of FIG. **4**.

At **550**, the location at which data resides in the cluster is provided. In some embodiments, **550** corresponds to, or is similar to, **450** of process **400** of FIG. **4**.

In response to determining to provide access to the data store at **520**, process **500** proceeds to **560** at which a storage location of data responsive to the data request is determined. In some embodiments, **560** corresponds to, or is similar to, **460** of process **400** of FIG. **4**.

At **570**, location of data responsive to the data request provided. In some embodiments, **570** corresponds to, or is similar to, **470** of process **400** of FIG. **4**.

At **580**, a determination is made as to whether process **500** is complete. In some embodiments, process **500** is determined to be complete in response to a determination that no further commands are to be performed or that no further data is to be accessed, a user has indicated that no further data is to be accessed, the user has exited the system, an administrator indicates that process **500** is to be paused or stopped, a determination that a fault occurred at the data store or in execution of code via the workspace, etc. In response to a determination that process **500** is complete, process **500** ends. In response to a determination that process **500** is not complete, process **500** returns to **510**. In some embodiments, a user does not access at all, and in that case the system will return an error indicating that the user does not have access rights.

FIG. **6** is a flow diagram of a method for providing access to data stored in a system for data storage according to various embodiments of the present application. According to various embodiments, process **600** is implemented at least in part by system **100** of FIG. **1** and/or system **200** of FIG. **2**. In some embodiments, process **600** is implemented in connection with process **300** of FIG. **3**, process **400** of FIG. **4**, and/or process **500** of FIG. **5**.

At **605**, a data request to access data is received. In some embodiments, the system receives the data request from a user such as via a user system. For example, in response to a user inputting a request to an interface (e.g., a web interface), the user system communicates the request to the system. In some embodiments, the managed data service (e.g., the metastore layer of the managed data service) intercepts the data request, or a control layer intercepts the data request and provides the request to the managed data service. The data corresponding to the data request is stored in a data store.

At **610**, a user associated with the data request is determined. In response to receiving the data request, the system determines the user associated with the data request. For example, the system determines the user associated with the user system from which the data request is received. In some embodiments, the data request comprises information indicating a user (e.g., a user identifier, a user system identifier, etc.).

At **615**, a determination of whether the user is authorized to access the data is performed. The system determines whether the user is authorized to access the data based on a permissions set associated with the user, the data corresponding to the data request, and/or the location at which the data is stored. In some embodiments, the stores (or has access to) a mapping of permissions such as a mapping of user identifiers for permitted users to data, a mapping of user identifiers for permitted users to types of data, a mapping of user identifiers for permitted users to locations of data (e.g., directories, tables, views, tenants, etc.), a mapping of groups of users to data, etc. As an example, the system uses a user identifier associated with a data request (e.g., included in the data request) to query the mapping of permissions in connection with determining whether the user is authorized to access the data corresponding to the data request.

In response to determining that the user is not authorized to access the data at **615**, process **600** proceeds to **620** at which access to the data is denied. In some embodiments, denying access comprises providing a notice to a user system. As an example, the notice indicates that the user does not have permission to access the data corresponding to the data request. The notice can be provided on a user interface at the user system (e.g., a web interface via which the user system communicates with managed data service, the data store, etc.).

In response to determining that the user is authorized to access the data at **615**, process **600** proceeds to **625** at which the data is determined to be provided via a secure cluster.

At **630**, a token is obtained for the user to access the data. In some embodiments, the system obtains the token based at least in part on one or more of the user associated with the data request (e.g., the user for whom the token is being provided), a location of the data, a system on which the location to be provided is stored (e.g., an instantiated secure cluster, the data store, etc.), etc. As an example, the system generates the token in response to determining that the user is authorized to access the data. As another example, the system requests that a credential system or an authentication system generates the token (e.g., based on parameters provided by the system such as comprised in the request for the token). In some embodiments, the token is time-limited (e.g., temporary, expires after a predetermined amount of time), and/or scope-limited (e.g., the credential is valid only with respect to a certain set of data such as data corresponding to the user access permissions, etc.).

At **635**, the token and location of the data is provided. In some embodiments, the system sends the token and the location of the data to the user (e.g., the user system). The token and/or the location may be comprised in a URL or a URI. In some embodiments, in response to receiving the token, the user system can access the data directly (e.g., without further mediation from the metastore at least with respect to such data and/or for such length of time that the token remains valid). The token and the location of the data can be provided via a web interface displayed at the user system.

At **640**, user input with respect to data stored in the cluster is received. In some embodiments, the system receives (or intercepts) a user input to data stored in the cluster. For example, the user inputs (via an interface on the user system) a modification to data in a table on the cluster. In some embodiments, the system mediates permitted user inputs based at least in part on the token with which the user accessed the data in the cluster, and/or a user corresponding to the user input.

At **645**, permitted user inputs to data stored in the cluster is synced with data stored in the data store. In some embodiments, the system syncs data provided to the user via the cluster with data stored in the data store. If a user modifies the data in the cluster an inconsistency is created between the data stored in the cluster and the data in the data store (e.g., from which the data in cluster was initially copied). Similarly, data in the data store may have been modified (e.g., by other users) since the cluster was instantiated and a copy of the data in the data store was written to the cluster. Accordingly, the system can sync the modifications across the cluster and the data store, or at least sync modifications made at the cluster with a current copy stored at the data store. Modifications to data in the cluster may be committed at the data store based at least in part on one or more conflict resolution policies.

At **650**, a determination is made as to whether process **600** is complete. In some embodiments, process **600** is determined to be complete in response to a determination that no further commands are to be performed or that no further data is to be accessed, a user has indicated that no further data is to be accessed, the user has exited the system, an administrator indicates that process **600** is to be paused or stopped, a determination that a fault occurred at the data store or in execution of code via the workspace, etc. In response to a determination that process **600** is complete, process **600** ends. In response to a determination that process **600** is not complete, process **600** returns to **605**.

Various examples of embodiments described herein are described in connection with flow diagrams. Although the examples may include certain steps performed in a particular order, according to various embodiments, various steps may be performed in various orders and/or various steps may be combined into a single step or in parallel.

Although the foregoing embodiments have been described in some detail for purposes of clarity of understanding, the invention is not limited to the details provided. There are many alternative ways of implementing the invention. The disclosed embodiments are illustrative and not restrictive.

What is claimed is:

1. A system, comprising:

one or more processors; and

a memory, coupled with the one or more processors, the memory comprising stored instructions executable by the one or more processors, the instructions when executed causes the one or more processors to:

receive a data request from a user;

determine data corresponding to the data request;

determine whether the user has requisite permissions to access the data; and

in response to a determination that the user has requisite permissions to access the data:

determine, based on an identity of the user, a manner by which to provide access to the data, wherein the data comprises a filtered subset of stored data, wherein the determination of the manner by which to provide access to the data further comprises instructions to determine whether to provide the data via a secure cluster or to provide data by providing access to a location at which the data is stored, wherein the secure cluster is a set of connected nodes;

in response to a determination to provide data via a secure cluster, instantiating a secure cluster;

copying the filtered subset of stored data from the location at which the data is stored to the instantiated secure cluster, wherein the filtered subset of stored data copied to the instantiated secure cluster may only be accessible to the user; and

generate a token based at least in part on the user and the instantiated secure cluster.

2. The system of claim **1**, wherein the filtered subset of the stored data is stored in a new structure, a file, or table.

3. The system of claim **2**, wherein the token enables access to an entity stored on the secure cluster.

4. The system of claim **3**, wherein the filtered subset of the stored data is transferred from a storage system without selective access control.

5. The system of claim **1**, further comprising:

in response to determining to provide data by providing access to a location at which the data is stored, providing a path to the location at which the data is stored.

6. The system of claim **1**, wherein:

a storage system storing the stored data allows only access to the filtered subset of the stored data based on the token;

the storage system constitutes certain data responsive to the data request; and

in response to receiving a request in connection with the token, the storage system permits access associated with the request to only a table that has been constituted.

7. The system of claim **6**, wherein the certain data is constituted based on permissions associated with the user.

8. The system of claim **1**, wherein:

the stored data is stored on a system for data storage; and

user requests to access data comprised in the system for data storage are mediated by a metastore layer.

9. The system of claim **8**, wherein the metastore layer stores an index of information comprised in the stored data.

10. The system of claim **8**, wherein the metastore layer stores metadata associated with information comprised in the stored data.

11. The system of claim **8**, wherein the metastore layer stores permissions for one or more users with respect to information comprised in the stored data.

12. The system of claim **1**, wherein an extent of a permission that the token provides with respect to the stored data is defined based on the data request.

13. The system of claim **1**, wherein the token expires after a preset period of time, at a preset time, or in response to an action.

14. The system of claim **1**, wherein the one or more processors are further configured to provide to the user the token with which the user is to access data responsive to the data request.

15. A method, comprising:

receiving, by one or more processors, a data request from a user;

determining data corresponding to the data request;

determining whether the user has requisite permissions to access the data; and

in response to determining that the user has requisite permissions to access the data:

determining, based on an identity of the user, a manner by which to provide access to the data, wherein the data comprises a filtered subset of stored data, wherein determining the manner by which to provide access to the data further comprises determining whether to provide the data via a secure cluster or to provide data by providing access to a location at which the data is stored, wherein the secure cluster is a set of connected nodes;

in response to determining to provide data via a secure cluster, instantiating a secure cluster;

copying the filtered subset of stored data from the location at which the data is stored to the instantiated secure cluster, wherein the filtered subset of stored data copied to the instantiated secure cluster may only be accessible to the user; and

a token based at least in part on the user and the instantiated secure cluster.

16. The method of claim **15**, the filtered subset of the stored data is stored in a new structure, a file, or table.

17. The method of claim **15**, wherein the token enables access to an entity stored on the secure cluster.

18. A computer program product embodied in a non-transitory computer readable medium and comprising computer instructions for:

receiving, by one or more processors, a data request from a user;

determining data corresponding to the data request;

determining whether the user has requisite permissions to access the data; and

in response to determining that the user has requisite permissions to access the data:

determining, based on an identity of the user, a manner by which to provide access to the data, wherein the data comprises a filtered subset of stored data, wherein determining the manner by which to provide access to the data further comprises determining whether to provide the data via a secure cluster or to provide data by providing access to a location at which the data is stored, wherein the secure cluster is a set of connected nodes;

in response to determining to provide data via a secure cluster, instantiating a secure cluster;

copying the filtered subset of stored data from the location at which the data is stored to the instantiated secure cluster, wherein the filtered subset of stored data copied to the instantiated secure cluster may only be accessible to the user; and

generating a token based at least in part on the user and the instantiated secure cluster.

19. The computer program product embodied in the non-transitory computer readable medium of claim **18**, the filtered subset of the stored data is stored in a new structure, a file, or table.

20. The computer program product embodied in the non-transitory computer readable medium of claim **18**, wherein the token enables access to an entity stored on the secure cluster.

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